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MONTANA ENERGY CONSERVATION PLAN

Working Paper No. 10

AVAILABILITY OF WOOD AS AN ENERGY SOURCE

A Report to the

Montana Energy Advisory Council

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INTRODUCTION

Current efforts to meet our State and National energy needs through balancing the use of finite and renewable resources have turned attention to wood as a source of energy.

Historically, wood served as the major source of energy in fueling the Industrial Revolution in this country. To evaluate its potential as a fuel source today requires a knowledge of the forest resource productivity, of the allocation of the resource, and of trends which favor the use of wood as a fuel.

1. FOREST RESOURCE EVALUATION

Montana's forest lands lie predominantly west of the Continental Divide. Forest covers 80% of western Montana, as compared to 12% of the land east of the Divide (Sweitzer, and others, 1975. See Map 1.1).

However, not all Montana forest lands are available or feasible for commercial timber. Table 1.1 displays the land area of Montana by land class. Only 10,097.7 thousand acres in western Montana and 5,921.4 thousand acres in eastern Montana of commercial forest land area is available.

Commercial Forest Land (CFL) is defined as forest land producing or capable of producing crops of industrial wood, which has not been withdrawn from timber utilization. The land has the capability of producing in excess of 20 cubic feet per acre per year under management. Currently inaccessible and inoperable areas are included, except when the areas involved are small and unlikely to become suitable for production in the foreseeable future. Of the CFL, only a portion is currently ready for timber production.

The percent of CFL available for timbering activity is reflected in data from the U. S. National Forests. The National Forests comprise the largest single ownership of forest land in Montana. (See Table 1.2.) As such, their land policies have a large impact on timber production.

Schweitzer and others (1975) report that in 1973, when one-seventh of the scheduled land-use planning had been completed, approximately 36% of the CFL National Forest land in Montana was considered ready, available, and suitable for normal timber production with standard harvesting practices and precautions. (See Table 1.3). This amounted to 6 million acres.

Table 1.1.--Land Areas in Montana, by Land Class, 1970

State	Total land area[1]	Total forest land area	Commercial forest land area				Noncommercial forest land area				Nonforest land area
			Total	Commercial	Deferred	Unregulated	Total	Unproductive reserved	Productive reserved	Unproductive	
	Thousand acres										
Western Montana	15,784.7	12,604.6	10,097.7	9,929.2	100.0	68.5	2,506.9	763.3	894.5	849.1	3,180
Eastern Montana	77,390.5	10,173.0	6,526.8	5,921.4	541.1	64.3	3,646.2	424.1	495.6	2,726.5	67,217

[1]From U. S. Bureau of the Census, Land and Water Area of the United States, 1970.

Source: Adapted from Green and Setzer, The Rocky Mountain Timber Situation. USDA Forest Service Resource Bulletin INT-10, November, 1974.

Table 1.2.--Approximate ownership pattern for Montana forest lands

	Thousand Acres	Percent
National Forests	16,526.7	72.6
Bureau of Land Management	478.0	2.1
Miscellaneous Federal	53.1	.2
Total Federal	17,057.8	74.9
Indian (including land held in trust by BIA)	620.2	2.7
State	529.5	2.3
County and municipal	4.7	--
Forest industry	1,055.4	4.6
Farmer	1,952.4	8.6
Other Private	1,557.6	6.8
Total Non-Federal	5,719.8	25.1
All forest land	22,777.8	100.0

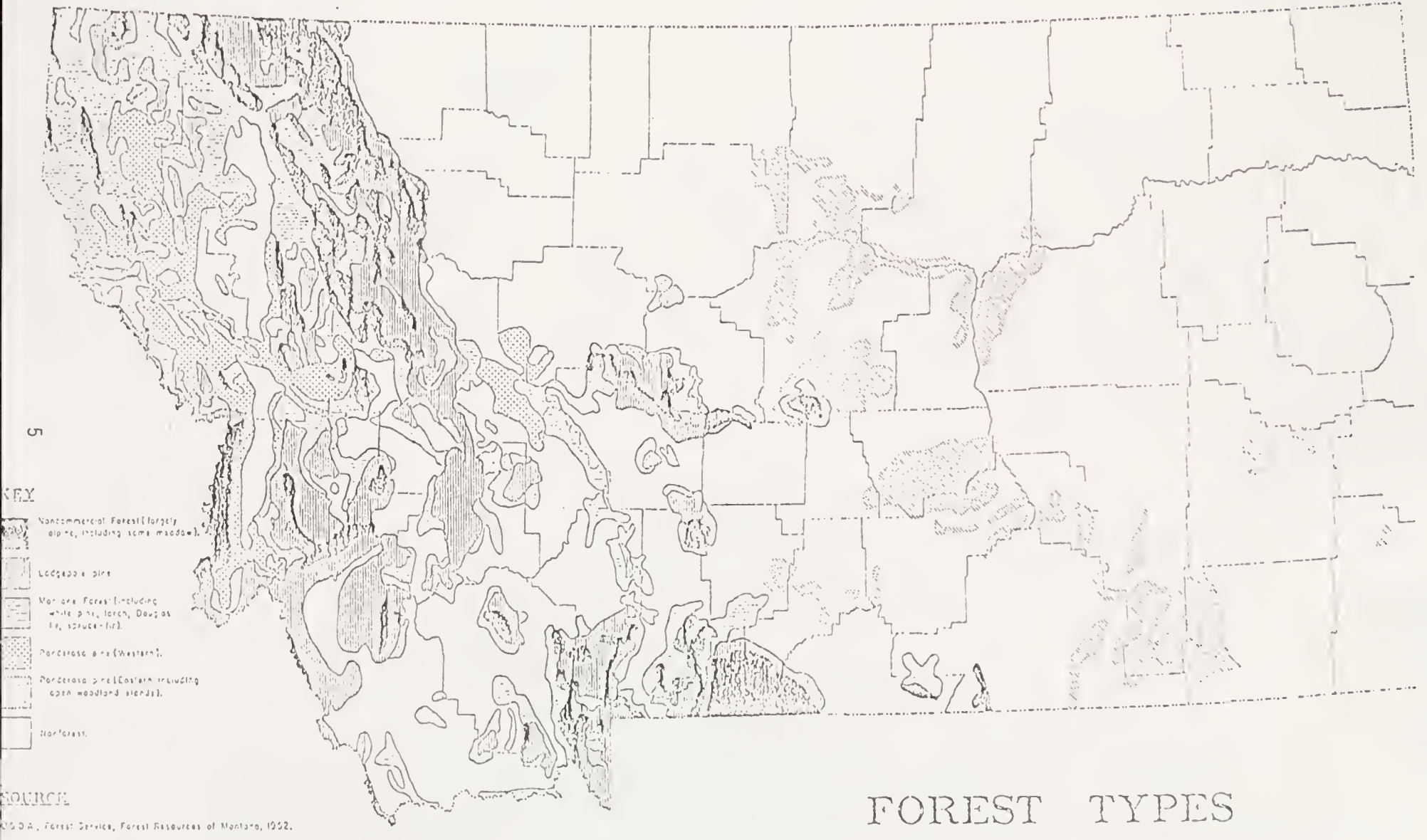
Source: Schweitzer, Benson, and McConnen. A Descriptive Analysis of Montana's Forest Resources. USDA Forest Service Resource Bulletin INT-11, January, 1975.

Citing: USDA Forest Service. The Outlook for Timber in the United States. For. Resour. Rep. 20, Washington, D. C. 1973.

Table 1.3.--The Status of Montana National Forest Lands, 1973

	Million Acres	Percent
COMMERCIAL FOREST LAND		
Standard (available and suitable for timber production with present technology)	6.0	36.4
Special (needs special timber production measures to protect other multiple use values)	.4	2.6
Marginal (areas not presently scheduled for harvest because of excessive development costs, low product values, or resource protection constraints)	2.5	15.2
Deferred (includes 0.5 million acres of New Wilderness Study Area, plus 0.3 million acres previously deferred)	.8	4.8
Subtotal Commercial	9.7	59.0
NONCOMMERCIAL AND MISCELLANEOUS	4.9	29.5
WILDERNESS	1.5	9.0
PRIMITIVE	.4	2.5
Total	16.5	100.0

Source: Schweitzer, Benson, and McConnen. A Descriptive Analysis of Montana's Forest Resources. USDA Forest Service Bulletin, INT-11, January, 1975.


KEY
Noncommercial Forest (largely alpine, including some meadow).
Lodgepole pine
Mountain Forest (including white pine, larch, Douglas fir, spruce-fir).
Ponderosa pine (Western).
Ponderosa pine (Eastern including open woodland stands).
Nonforest.
SOURCE
U.S.D.A., Forest Service, Forest Resources of Montana, 1952.

FOREST TYPES

Map 1.1

It is expected that the land area of CFL in Montana will stabilize after 1980. By that date, decisions regarding land use of marginal and deferred land for such purposes as inclusion in the Wilderness System will be complete.

Montana lumber output is concentrated in six counties. (See Table 1.4.)

Table 1.4.--County of origin of logs in Montana, 1969

County	Share of logs (Percent)	Principal species by volume
Lincoln	39	Western larch, Douglas-fir, ponderosa pine
Flathead	17	Engelmann spruce, Douglas-fir
Missoula	9	Ponderosa pine, Douglas-fir
Lake	6	Western larch, Douglas-fir
Ravalli	6	Douglas-fir, ponderosa pine
Sanders	5	Ponderosa pine, Douglas-fir
Others	18	Ponderosa pine, Douglas-fir
	100	

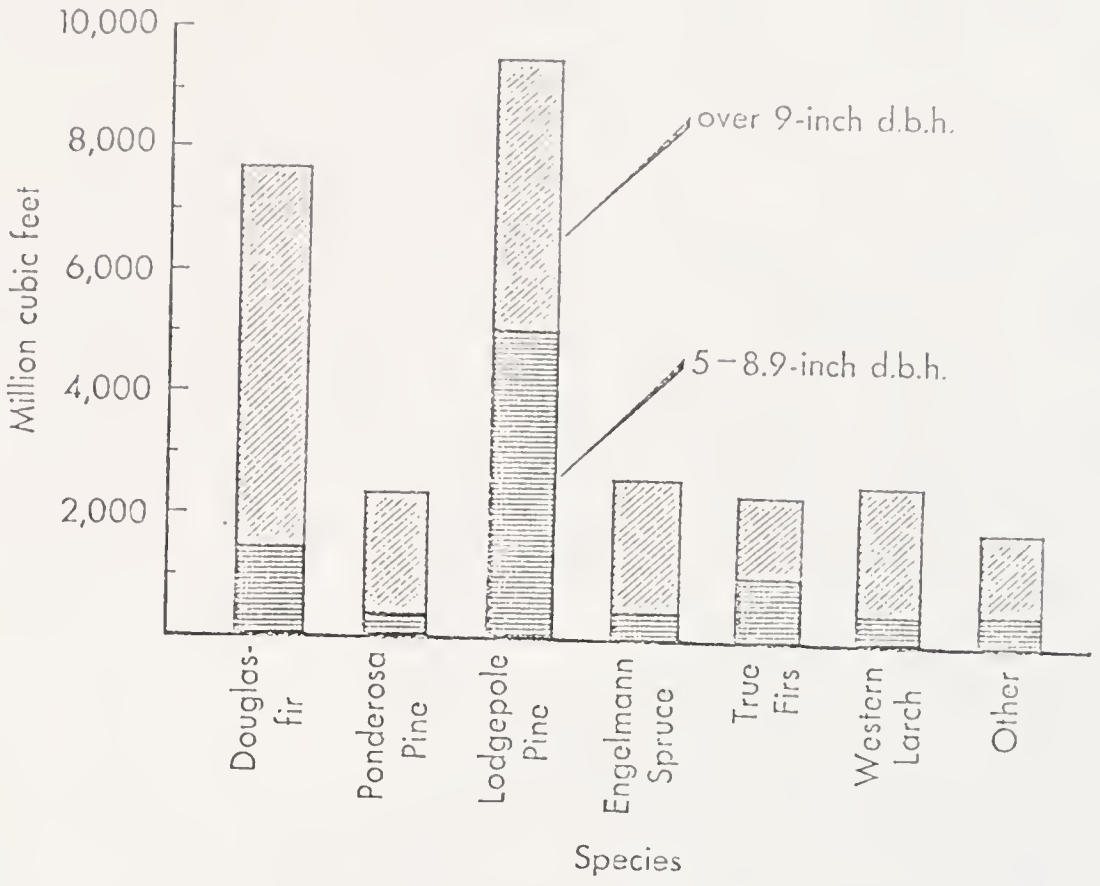
Source: Schweitzer and others, 1975.

Citing: Setzer, 1971.

Trends in the growth and removal of Montana forests were reported by Schweitzer and others (1975).

Figure 1.1 displays the net volume of growing stock on CFL in Montana in 1970.

Figure 1.1.--Net volume of growing stock on commercial Forest Lands in Montana by Species and Size Class, 1970



Source: Schweitzer and others, 1975

Citing: Green and Setzer, 1974

Net annual growth (see Table 1.5) was about 1.5 percent of growing stock volume. Removals (see Table 1.6) totaled more than 1 percent per year. This rate of removal allowed an estimated increase in growing stock of 0.5 percent per year.

Table 1.5.--Net Annual Growth of Growing Stock and Sawtimber on Commercial Forest Land in Montana by Softwoods and Hardwoods

State	All owner groups	National Forest	Other Public	Forest Industry	Other Private	All owner groups	National Forest	Other Public	Forest Industry	Other Private
	Thousand cubic feet growing stock					Thousand board feet sawtimber				
Western Montana:										
Softwoods	334,582	227,482	27,369	28,299	51,432	1,173,354	738,354	113,346	129,050	192,604
Hardwoods	1,280	480	122	136	542	4,673	673	862	813	2,325
All species	335,862	227,962	27,491	28,435	51,974	1,178,027	739,027	114,208	129,863	194,929
Eastern Montana:										
Softwoods	105,062	58,862	13,208	194	32,808	300,046	187,046	32,218	529	80,253
Hardwoods	2,218	118	588	---	1,512	8,168	168	2,226	---	5,774
All species	107,280	58,980	13,796	194	34,320	308,214	187,214	34,444	529	86,027

Source: Adapted from Green and Setzer, 1974.

[1] International 1/4-inch rule.

Table 1.6.--Removals from Growing Stock on Commercial Forest Land in Montana by Roundwood Products, Logging Residues, and Other Removals, 1970

State	Total Removals	PRODUCTS									Logging Residues	Other Removals
		All Products	Saw Logs	Veneer Logs	Pulpwood	Commercial Poles	Ripe Timber	Miscellaneous Industrial Wood	Posts, Miscellaneous Farm Timbers	Fuelwood		
	Thousand cubic feet											
Western Montana	292,043	248,379	210,787	32,072	1,480	720	1,640	573	1,127		39,142	4,522
Eastern Montana	32,361	36,926	26,219	---	182	90	204	71	140		4,872	563

Source: Adapted from Green and Setzer, 1974.

[1] Includes house logs, converter poles, piting, shingle bolts, excelsior bolts, batch stock, charcoal wood, and similar items.

Annual mortality was substantial. (See Table 1.7.) Losses to mortality--insects, disease, and fire--total about 0.6 billion board feet annually.

Actual harvests in Montana have generally been less than the calculated allowable harvest. Allowable harvest is the volume of timber which is calculated to meet long term planning objectives and aimed at sustained production of timber products. Since 1969, the actual harvest has declined due to classification of forest land and shortages of personnel in administering sales. The authors also noted that logging contractors have been reluctant to invest in expensive, advanced equipment or harvest lower value timber partially because few of these systems have been thoroughly tested in the state.

The authors report that, in 1972, 3.25 million acres of National Forest lands needed either regeneration or stocking control in Region One (which includes northern Idaho). About 60,000 acres of National Forest lands in the state were nonstocked.

Green and Setzer (1974) made several projections concerning the probable consequences of continuing 1970 forestry practices in the Rocky Mountain Region on National Forest Lands.

The authors held that sawtimber cut cannot be maintained at present levels. A probable decrease in sawtimber harvest of 8% or more by the year 2,000 is expected due to a shortage of large trees. In order to prevent an overgrowth of small trees resulting in slow growth and significant suppression mortality, "at least a fivefold increase in precommercial thinning" is required. With a continuation of present allowable cubic-foot cut, smaller size trees will comprise increasing volumes of the harvest.

Table 1.7.--Annual Mortality of Growing Stock and Sawtimber on Commercial Forest Land in Montana by Softwoods and Hardwoods and Owner Group, 1970

State	All Owner Groups	National Forest	Other Public	Forest Industry	Other Private	All Owner Groups	National Forest	Other Public	Forest Industry	Other Private
	Thousand cubic feet growing stock					Thousand board feet sawtimber[1]				
Western Montana:										
Softwoods	110,040	80,140	6,734	12,862	10,304	418,939	292,939	23,333	56,667	41,000
Hardwoods	481	281	14	9	177	1,171	1,171	---	---	---
All Species	110,521	80,421	6,748	12,871	10,481	420,110	294,110	2#,333	56,667	41,000
Eastern Montana:										
Softwoods	51,831	22,331	8,513	53	20,929	159,402	72,402	25,110	175	61,715
Hardwoods	1,504	4	433	--	1,067	6,006	6	1,733	---	4,267
All Species	53,335	22,335	8,946	53	21,996	165,408	72,408	26,843	175	65,982

Source: Adapted from Green and Setzer, 1974.

[1] International 1/4-inch rule.

On industrial owned lands, removals have exceeded growth for at least two decades. They cannot be expected to provide much of the future sawlog output.

On National Forest Lands, decreased production, as reflected in not attaining the annual allowable cut, is due to several reasons. First of all, the allowable cut has been revised upward due to changes in utilization standards. Further, budgetary constraints have precluded hiring, and the necessity for environmental impact statements on timber sales have delayed sales.

Green and Setzer (1974) hold that a variety of factors will effect the timber supplies in the Rocky Mountains in the future.

Land use policies will affect the allotment of land for commercial forest purposes. As stated earlier, land use decisions are expected to stablize by 1980. The productivity of the land is also an important influence. In 1970, there were about 2.7 million acres of nonstocked productive land in the Rocky Mountains. The authors state that a regeneration program 6 times the magnitude of the 1970 program would be required to eliminate the backlog and assure prompt regeneration of future cuts. These and other activities such as insect and disease control and precommercial thinning will increase the supply in the long run.

About 247,000 acres are cutover annually in the Rocky Mountain Region. Planting and seeding efforts regenerate 70,000 acres and natural regeneration takes place on 12,000 acres annually. About 92,000 acres received timber stand improvement work (Green and Setzer, 1974).

Schweitzer and others (1975) summarized the impacts which changes in timber management could have on harvest levels. (See Table 1.8.)

Table 1.8.--Rough Estimates of Maximum Impacts on Harvest Levels by Changes in Timber Management

	Change in Annual Allowable Harvest (Percent)
All roadless areas removed from commercial forest land base	-35
Marginal areas do not become available for harvest	-15
More time required to replace old growth with second-growth stands	-15
Less time required to replace old growth with second-growth stands	20
Intensive management (reforestation and thinning)	20 to 30
Tree improvement (harvest increase in 30 to 40 years)	15
Utilization improvement	25

Source: Schweitzer and others, 1975.

Note: The impacts are not additive.

Schallau (1975) reports, "Timber supply to the year 2,020, for the most part, will be derived from existing stands." He cites the USDA 1973 prediction--that the U. S. potential softwood timber supply is estimated to increase by only 31 percent by the year 2,000. This potential may not be realized due to "factors of operability and owners' willingness to sell timber." Schallau says, "potential improvements in supply through intensified management may be overstated."

Barger (1976) reports that the USDA FS study of the timber outlook (USDA FS 1973) predicts substantial increases in the demand for wood and wood fiber-based products, especially softwood construction products. Based on 1970 prices, it is expected that demand will exceed supply by 20 billion bd. ft. by the year 2,000.

In order to meet this demand, Barger says, "In the long run, a variety of efforts will be needed to resolve timber supply problems--among these may be more intensive timber management, better protection, more recycling, and more efficient construction design. In the short run, however, it appears that more complete recovery and use of the total available wood resource is the most effective way to add to timber supply."

Schallau (1976) evaluated the potential of the Rocky Mountain states to produce timber: "Although timber output in the Rocky Mountain region doubled between 1952 and 1970, we appear to have reached a plateau . . . we can no longer rely on nature to provide the additions. In other words, intensified forestry is the key."

In the short run, Schallau stressed opportunities to utilize logging residues and reduce insect and disease losses. In the long run, he stated the need for accelerated reforestation of backlog areas, superior planting stock, and accelerated thinning but acknowledged, "We do not have the funding to do what is necessary . . . Congressional approval will be important if intensified forestry is to be significantly increased because the amount of public lands involved is large."

Slash may also be disposed of by chipping residues on site. The Forest Service reports on a 1971 research study area in Wyoming where chips were spread on the site. The Volume obtained was approximately 11,000 cu. ft. Cost was approximately $10.00/ton.

An alternate method of disposal is burying slash. Ward and McLean (1976) report that the operation cost of burying slash is about $83 per acre (1975 price). This method can usually be used on a one-time basis only. Stable soils and gentle slopes are also preferred to decrease erosion.

The following costs were reported as the contract slash disposal cost ranges in Region One (Hearst, January, 1977):

Method	Cost Per Acre
Broadcast burn	$ 35 - 70
Handpile and burn	$150 - 300
Jackpot burn	$ 15 - 20
Dozer pile and burn	$ 40 - 70

Source: Hearst Letter to Report Author, January 21, 1977

SUMMARY

Montana's forest lands lie mainly in the western half of the State; timber production is concentrated in six counties, with three counties producing about three-fourths of the logs.

Forest lands in the State are mainly federally owned; National Forest policies greatly influence timber production in the state.

Although actual harvests in Montana have generally been less than the allowable harvests, the literature predicts that, with the present level of management, a sawtimber harvest is predicted to decline by the year 2000. A factor which is reported to influence this decline is the backlogging of forest management practices such as regeneration and thinning.

The majority of the evidence suggests that the demand for wood products will increase to the year 2000. To meet this demand, both short and long term efforts are necessary. Short term efforts include more complete recovery and use of the wood resource. Long term efforts include reforestation and thinning; however, federal funding to support these practices is questionable.

2. FOREST RESIDUES

The present volume of timber on commercial forests in Montana is shown in Table 2.1.

Twelve percent of this volume (3,000.7 million cu. ft.) is salvable dead timber, the majority of which lies in western Montana.

Barger (1976) states that this dead timber resulted largely from insect and disease damage. It can remain sound for many years on the relatively cold dry sites common to Montana. This amount of timber is "Roughly equivalent to twelve years allowable cut at present harvesting levels."

In addition to the volume of dead timber presently on CFL, each year forest residues are produced due to a number of factors including annual mortality and saw log operations.

Montana's annual mortality of growing stock and saw timber on CFL in 1970 was 110,521 thousand cubic feet in the west and 53,335 in the east. (See Table 2.2.)

The annual Montana sawtimber mortality on CFL is compared to that of other states in the Rocky Mountain region in Table 2.3. Montana and Idaho comprised almost two-thirds of the annual sawtimber mortality in the region.

Logging Residues

Green and Setzer (1974) report in Table 2.4 that removals from growing stock in Montana in 1970 of 324,404 thousand cu. ft. produced 44,014 thousand cu. ft. of logging residues.

Table 2.1.--Net Volume of Timber on Commercial Forest Land in Montana by Timber Class and Softwoods and Hardwoods, 1970

State	All Timber Classes			Growing Stock			Sound Cull Trees			Rotten Cull Trees			Salvable Dead Trees		
	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods
	Million cubic feet														
Western Montana	22,357.2	22,260.3	96.8	19,450.0	19,372.3	77.7	399.1	384.4	14.7	481.4	478.2	3.2	2,026.6	2,025.4	1.2
Eastern Montana	10,824.8	10,601.5	223.3	9,200.0	9,004.0	196.0	447.2	418.7	8.5	203.5	193.9	9.6	974.1	954.9	9.2

Source: Adapted from Green and Setzer, The Rocky Mountain Timber Situation, USDA Forest Service Bulletin INT-10, November 1974.

Note: Salvable dead trees include standing or down dead trees that are considered merchantable by Regional Standards.

Table 2.2.--Annual Mortality of Growing Stock and Sawtimber on Commercial Forest Land in Montana by Softwoods and Hardwoods and Owner Group, 1970

State	All Owner Groups	National Forest	Other Public	Forest Industry	Other Private	All Owner Groups	National Forest	Other Public	Forest Industry	Other Private
	Thousand cubic feet growing stock					Thousand board feet sawtimber[1]				
Western Montana:										
Softwoods	110,040	80,140	6,734	12,862	10,304	418,939	292,939	28,333	56,667	41,000
Hardwoods	481	281	14	9	177	1,171	1,171	---	---	---
All Species	110,521	80,421	6,748	12,871	10,481	420,119	294,110	28,333	56,667	41,000
Eastern Montana:										
Softwoods	51,831	22,331	8,513	58	20,929	159,402	72,402	25,110	175	61,715
Hardwoods	1,504	4	433	--	1,067	6,006	6	1,733	--	4,267
All Species	53,335	22,335	8,946	58	21,996	165,408	72,408	26,843	175	65,982

Source: Adapted from Green and Setzer, 1974.

[1]International 1/4-inch rule.

Table 2.3.--Annual Mortality of Sawtimber on Commercial Forest Land in the Rocky Mountain States

State	Mortality	Percent of Total
	Million bd. ft.	
Idaho	969.7	39
Montana	585.5	24
Wyoming	90.0	4
South Dakota	5.5	< 1
Arizona	67.0	3
Colorado	334.0	13
Nevada	9.0	< 1
New Mexico	170.4	7
Utah	243.7	10
Total	2,474.8	100

Source: Green and Setzer, 1974

Table 2.4.--Total Removals from Growing Stock on Commercial Forest Land by Roundwood Products, Logging Residues, and other Removals, 1970

State	Total Removals	PRODUCTS									
		All Products	Saw Logs	Veneer Logs	Pulpwood	Commercial Poles	Ripe Timbers	Miscellaneous Industrial Wood	Posts, Miscellaneous Farm Timbers	Fuelwood	Logging Residues	Other Removals
	Thousand cubic feet											
Western Montana	292,043	248,379	210,787	32,072	1,440	720	1,640	573	1,127		39,142	4,522
Eastern Montana	32,361	36,926	26,219	---	182	90	204	71	140		4,872	563

Source: Adapted from Green and Setzer, 1974.

Note: Growing Stock includes live trees meeting specified standards of quality or vigor; excludes cull trees.

[1] Includes house logs, converter poles, piling, shingle bolts, excelsior bolts, match stock, charcoal wood, and similar items.

Gareth C. Moon, Administrator in the Division of Forestry of the Montana Department of Natural Resources and Conservation, estimated that approximately 167,000 thousand board feet of wood was harvested in 1975. "This produced just over 27,000 thousand board feet of logging residues which for the most part was either burned as slash or unutilized." (Extract of letter sent to Lt. Governor Bill Christensen, August 26, 1976.)

Inannassi (1975) reports that on the average, 55% of the weight of each tree harvested actually reaches the mill. The remainder is left in the forest because it is unsuitable for pulping. Inannazzi states, "We are approaching the energy price level at which that part of the tree which now is not used may be recovered for its energy value."

Various studies report the amount of residues per acre which results from logging. The Forest Service reports (USDA Forest Service, 1974) on the volume of slash created annually. Slash is defined as the wood residue remaining after logging, thinning, road building or clearing operations. It includes foliage, twigs, branches, bark, tops, stumps, and unutilized or cull logs and trees.

An annual average of 110,000 acres of slash was created on National Forest lands in Region I (most of Montana and part of northern Idaho) during the years 1968-1972. Assuming an average of over 100 tons per acre (ovendry weight) remains after logging, the report shows that an estimated 12 million tons of slash residue is generated on National Forest lands within Region I each year.

Hearst (1975) estimates the total annual volume of wood residue in Region I of the National Forest. The Forest Service harvests approximately 90,000 acres and clears 18,000-19,000 acres for timber management program

roads. This totals 108,000-109,000 acres with an average of 100 tons of residue per acre for a total of 11 million tons of woods residue.

"In Region One, more than half of the sawtimber harvest comes from lands other than National Forest," (BLM, BIA, states, and private forest land). To this volume must be added the debris from cultural work in National Forests on approximately 90,000 acres, cultural work on other lands, and from clearing for agriculture, powerlines, pipelines, and highways.

"Conservatively, it has been estimated that more than 25 million tons of forest debris are generated annually within the boundaries of the Region, exclusive of timber mortality due to insects, disease, and fire."

The volume of forest residue remaining following logging has been reported to vary according to species, utilization specifications, and other factors.

Benson and Johnson (1976) report on a comparative study of residues remaining following conventional logging and close utilization logging in the Northern Rocky Mountain Region. On most close utilization sites, material down to a 3 inch diameter was removed (either field chipped or logged). On conventionally logged sites, material down to a 6 or 8 inch top was removed. The authors reported that the volume of residues was largest in clearcut units with conventional utilization (average 2,958 ft^3/acre) and smallest in partial cuts with close utilization (average 1,131 ft^3/acre).

Barger (1976) in citing Benson and Johnson's work notes that residue from clearcutting with conventional utilization averaged 35% of the initial cubic volume (3 inch and larger diameter remaining as residue) and amounted

to approximately 3,000 ft^3/acre. Residues from close utilization averaged 20% of the initial volume remaining. Volume also varied with timber type: Larch/Douglas fir had the lowest residual volume (2,564 ft^3/acre) while Lodgepole pine had the highest (3,567 ft^3/acre).

Barger (1976) reported that in a recent study by Foulger and Harris (1973) residues remaining following conventional clearcutting averaged 4,33.1 ft^3/acre. On areas designated for close utilization, where all material not merchantable as logs was chipped with a whole-tree field chipper, 45 oven dry tons of chips per acre were recovered, representing a 35% increase in total fiber recovery.

Withycombe (1975a) reports on the availability of 5-D* wood. These trees are "dead, dying, down, diseased, or defective." They are unmerchantable timber, not suitable for sawlogs, which may be usable as a source of wood fiber. Availability of this material depends on the area being opened for logging since the value of the material is too low to support road building.

Availability of 5-D wood in Forest Service District One which is economically accessible to the Missoula Hoerner-Waldorf mill has been estimated. Annaully, approximately .6 million tons are readily available and .7 million tons are probably available, depending on new access roads or increases in public timber sales. Withycombe reports that there is some overlap between the logging residue estimates and 5-D wood.

* Trademark applied for by Hoerner-Waldorf Corporation.

Forest Residue Management--The Forest Service Slash Disposal Program

The Forest Service has determined that it is necessary to treat the volume of residue left by logging operations.

The Forest Service (USDA Forest Service, 1974) reports that the principal reasons for slash treatment include improving regrowth potential, preventing insect buildup, controlling forest diseases, reducing the aesthetic impacts of slash accumulation, and reducing obstacles to movement of domestic animals and wildlife. "Untreated slash is more flammable and presents a greater fire hazard than that existing before logging. (It) does not readily deteriorate in the northern latitudes and can remain as a serious and intolerable fire hazard for decades."

Options for slash treatment include:

Prescribed burning: broadcast and spot burning, and burning of hand or dozer piles;

Mechanical treatments: burying, trampling, chipping, chopping, crushing, rolling and high intensity burning;

Isolation and limited treatments: construction of fire and/or fuel breaks, or

No treatment.

Table 2.5 summarizes the annual fuel treatment accomplishment reports for Region I from 1968-72.

On the average, 59% of the land on which slash was created was treated. Burning slash (both broadcast and piling) was performed on 77% of the acres.

Table 2.5.--Summary of Annual Fuel Treatment Accomplishment Reports (National Forest Lands in Region One)

Fiscal Year	Acres Slash Created	Acres Slash Disposal Accomplished: Broadcast Burn	Piling & Burning	All Other Treatments	Total	% Treated
1968	102,239	14,942	25,583	15,492	56,017	54.8%
1969	107,756	23,763	23,072	14,906	61,741	57.3%
1970	113,372	15,656	28,335	16,428	60,419	53.3%
1971	119,955	25,332	41,769	15,742	82,843	69.1%
1972	104,861	18,223	32,997	10,528	61,748	58.9%
Total	548,183	97,916	151,756	73,096	322,768	58.9%
Average	109,637	19,583	30,351	14,619	64,553	58.9%
% Accomplished by Treatments		30%	47%	23%	100%	---

Source: USDA Forest Service, 1974.

Cost per acre present slash treatment methods vary markedly. The Forest Service reports, "This variability makes averages nearly meaningless. Individual project costs vary according to the following factors: size of area; species and tree size; distance to job and accessibility; slope and terrain; residual stand; silvicultural treatment and objectives; volume, size, arrangement, etc., of slash; management objectives; degree of utilization; financing available; weather; reliability of data reporting system; etc."

Table 2.6 summarizes treatment costs for 1968-1972. However, overhead and many indirect costs are not included in these totals.

Table 2.6.--Summary of Annual Fuel Treatment Accomplishment Reports Including Costs (National Forest Lands in Region One)

	Method of Treatment											
	Broadcast Burning			Piling and Burning			All Other Treatments			Total		
Fiscal Year	Acres Treated	Cost $	Cost/ Acre $	Acres Treated	Cost $	Cost/ Acre $	Acres Treated	Cost $	Cost/ Acre $	Acres Treated	Cost $	Cost/ Acre $
1968	14,942	435,555	29.15	25,581	745,732	29.15	15,492	215,956	13.94	56,017	1,397,243	24.94
1969	23,763	657,027	27.65	23,072	971,611	42.20	14,906	177,818	11.93	61,741	1,808,456	29.29
1970	15,656	292,449	18.68	28,335	936,988	33.07	16,428	282,140	17.17	60,419	1,511,577	25.02
1971	25,332	631,244	24.92	41,769	1,355,721	32.45	15,742	331,102	21.33	82,843	2,318,067	27.98
1972	18,223	620,896	34.07	32,597	1,173,679	35.57	10,528	135,199	12.84	61,748	1,929,772	31.25
Total	97,916	2,637,169	26.93	151,755	5,185,731	34.17	73,096	1,142,215	15.63	322,768	8,965,115	27.78
Average	19,583	527,433	26.93	30,351	1,037,146	34.17	14,619	223,443	15.63	64,553	1,793,023	27.78
% of Total	30%	29%	--	47%	58%	--	23%	13%	--	100%	100%	--

Source: USDA Forest Service, 1974

Table 2.7 presents a more detailed report in order to show acre of specific treatment methods. These projects were completed during Fall, 1972.

Table 2.7.--Costs of Specific Fuel Treatments During Fall, 1972
(National Forest Lands in Region One)

Method of Treatment	No. of Projects	Acres Treated	Total Costs Reported	Average Cost/ Acre $	Range $ Cost/Acre Minimum	Range $ Cost/Acre Maximum	Range Project Size - Acres Minimum	Range Project Size - Acres Maximum
Broadcast Burning	32	3,261	70,243	21.54	6.17	89.19	13	655
Slashing (Preparation for Broadcast Burn)	17	1,248	15,779	12.64	.23	49.25	5	442
Hand Pile Slash	5	67	3,065	45.75	.27	508.47	2	52
Hand Pile and Burn	17	453	18,965	41.87	3.82	802.49	1	90
Machine Pile and Scarify	29	3,666	122,300	33.36	.08	227.70	3	684
Machine Pile, Scarify and Burn	4	131	4,985	38.05	23.62	109.21	11	80
Burn (only: Dozer Piles	55	5,325	79,883	15.00	.17	857.01	2	789
Jackpot Burning	1	336	3,819	11.37	--	--	--	--
Snagging	1	4	220	52.45	--	--	--	--
Fireline Construction	1	35	352	10.05	--	--	-	--

Source: USDA Forest Service, 1974

SUMMARY

The literature shows that Montana has the second highest rate of timber mortality in the Rocky Mountain States. A portion of this material, classified as 5-D wood, has been shown to be economically accessible for pulpwood manufacture.

Forest residues are further increased by logging operations. Studies have shown that the volume of logging residues varies with types of logging operations. Close utilization logging has been shown to increase the wood fiber recovery at a moderate cost.

Present management of forest residue is directed toward improving forest regeneration and decreasing impacts such as fire hazards and obstructed game movement. From 1968-1972, only 59% of the land on which slash was created was treated. Average costs of treating forest residues are reported to vary widely, ranging from $15 to $300 per acre.

Various studies report the amount of residues per acre which results from logging. The Forest Service reports (USDA Forest Service, 1974) on the volume of slash created annually. Slash is defined as the wood residue remaining after logging, thinning, road building or clearing operations. It includes foliage, twigs, branches, bark, tops, stumps, and unutilized or cull logs and trees.

An annual average of 110,000 acres of slash was created on National Forest lands in Region I (most of Montana and part of northern Idaho) during the years 1968-1972. Assuming an average of over 100 tons per acre (ovendry weight) remaining after logging, the report shows that an estimated 12 million tons of slash residue is generated on National Forest lands within Region I each year.

Hearst (1975) estimates the total annual volume of wood residue in Region I of the National Forest. The Forest Service harvests approximately 90,000 acres and clears 18,000-19,000 acres for timber management program roads. This totals 108,000-109,000 acres with an average of 100 tons of residue per acre for a total of 11 million tons of woods residue.

"In Region One, more than half of the sawtimber harvest comes from lands other than National Forest" (BLM, BIA, states, and private forest land). To this volume must be added the debris from cultural work in National Forests on approximately 90,000 acres, cultural work on other lands, and from clearing for agriculture, powerlines, pipelines, and highways.

"Conservatively, it has been estimated that more than 25 million tons of forest debris are generated annually within the boundaries of the Region, exclusive of timber mortality due to insects, disease, and fire."

The volume of forest residue remaining following logging has been reported to vary according to species, utilization specifications, and other factors.

Benson and Johnson (1976) report on a comparative study of residues remaining following conventional logging and close utilization logging in the Northern Rocky Mountain Region. On most close utilization sites, material down to a 3 inch diameter was removed (either field chipped or logged). On conventionally logged sites, material down to a 6 or 8 inch top was removed. The authors reported that the volume of residues was largest in clearcut units with conventional utilization (average 2,958 ft^3/acre) and smallest in partial cuts with close utilization (average 1,131 ft^3/acre).

Barger (1976) in citing Benson and Johnson's work notes that residue from clearcutting with conventional utilization averaged 35% of the initial cubic volume (3 inch and larger diameter remaining as residue) and amounted to approximately 3,000 ft^3/acre. Residues from close utilization averaged 20% of the initial volume remaining. Volume also varied with timber type: Larch/Douglas fir had the lowest residual volume (2,564 ft^3/acre) while Lodgepole pine had the highest (3,567 ft^3/acre).

Barger (1976) reported that in a recent study by Foulger and Harris (1973) residues remaining following conventional clearcutting averaged 4,333.1 ft^3/acre. On areas designated for close utilization, where all material not merchantable as logs was chipped with a whole-tree field chipper, 45 oven dry tons of chips per acre were recovered, representing a 35% increase in total fiber recovery.

Withycombe (1975a) reports on the availability of 5-D* wood. These trees are "dead, dying, down, diseased, or defective." They are unmerchantable timber, not suitable for sawlogs, which may be usable as a source of wood fiber. Availability of this material depends on the area being opened for logging since the value of the material is too low to support road building.

Availability of 5-D wood in Forest Service District One which is economically accessible to the Missoula Hoerner-Waldorf mill has been estimated. Annually, approximately .6 million tons are readily available and .7 million tons are probably available, depending on new access roads or increases in public timber sales. Withycombe reports that there is some overlap between the logging residue estimates and 5-D wood.

* Trademark applied for by Hoerner-Waldorf Corporation.

3. MILL RESIDUES

The estimated volume of used and unused plant residues from lumber, veneer and plywood industries in Montana in 1969 was reported by Setzer (1971). (See Table 3.1.) About 28 percent of the bark was utilized mainly for fuel. More than 86 percent of the coarse residues was used mainly for pulpwood. About 60 percent of the fine residues was used mostly for fuel.

Table 3.1.--Estimated Volume of Used and Unused Plant Residues from the Lumber and Veneer and Plywood Industries in Montana, 1969

Year	Bark			Coarse[1]			Fine[2]		
	Total	Used	Unused	Total	Used	Unused	Total	Used	Unused
	Thousand cubic feet								
1969	37,913	10,552	27,361	61,302	53,075	8,227	57,015	34,152	22,863

[1]Material suitable for chipping, such as slabs, edgings, and trimmings.

[2]Material such as sawdust and shavings.

Withycombe (1975b) estimates the concentrations of mill wastes in the Northern Rocky Mountains in Table 3.2. He notes that this survey (the Forest Industries annual survey, Lambert, 1973) is not complete but does include most larger mills and is adequate for locating mill waste concentrations. Mills are located in this survey according to the river drainages on which they lie.

Although the land which is drained by the four Montana rivers--Kootenai, Flathead, Lower and Upper Clark Fork--does not lie entirely in Montana, the table is still useful in locating unused mill wastes and the identifying types of mill waste which are unused.

Table 3.2.--Northern Rocky Mountain Mill Waste Estimate, 1972

Type of mill waste		Location of mill or plywood plant								
		Kootenai	Flathead	Lower Clark Fork	Upper Clark Fork	East side Montana	Coeur d'Alene	Clearwater	Lower Snake	Upper Snake
Sawmill production (million bd ft)	(1)	312	340	162	251	89	550	510	449	145
Production by mills over 20 million bd ft yr	(2)	305	307	162	245	0	465	455	459	119
Chips (1,000 tons)	(3)	157	158	84	126	0	239	224	227	57
Sawdust (1,000 tons)	(4)	80	81	43	65	0	122	115	155	29
Shavings (1,000 tons)	(5)	55	59	31	47	0	89	84	84	21
Plywood production (million ft^2)	(6)	70	215		210		145	300		
Green chips (1,000 tons)	(7)	24	74		73		50	101		
Dry trim (1,000 tons)	(8)	6	19		13		13	26		
Total green chips (1,000 tons)	(9)	181	232	84	199	0	289	233	227	57
Total fine wastes (1,000 tons)	(10)	144	159	74	130		224	225	240	50
Already committed to particleboard (1,000 tons)	(11)		120		155		30			
Unused fine wastes (1,000 tons)	(12)	144	39	74			194	225	240	50

Source: Withycombe, 1975-6

Withycombe states that due to these large supplies of fine mill wastes (sawdust, shavings, dry trim) in the Northern Rockies and shrinking supplies elsewhere, the particleboard industry will be building in this region within the near future. He holds that these plants will have most of the fine mill waste committed to production within the next five years.

Barger (1976) holds that in the Northern Rocky Mountain area, a relatively close balance between shippable mill wastes and pulpwood demand exists with little room for expansion. For example, by the end of 1974, Hoerner-Waldorf had established permanent chipping facilities at Missoula, Columbia Falls, and Dillon in order to convert roundwood to ships (Schweitzer and Others, 1974). Three portable chippers were located at various lumber production centers including Darby, White Sulpher Springs, Belgrade, and Livingston.

Barger expects that only after the cost of mill waste chips approaches the cost of handling and chipping forest residues will the forest residues come into use for such purposes as pulpwood production.

Withycombe (1975a) holds that the long-term (this decade) prospects for mill waste utilization appear to be good. "Most of the waste material suitable for pulping is already being used . . . Particle board plants presently use more than half the available shavings." He expects several new plants in the region in the next few years will use the remainder. "Mill waste, as a wasted material, will cease to exist except for small amounts in small scattered mills."

A recent report (Moore, 1976) on the production, usage, and revenue patterns for the residue products of 79 sawmills in Oregon and California is useful for evaluating trends in mill residue. The object of the study was to determine the current uses, values, and production of sawmill residues and identify the market requirements for wood-fired energy conversion systems. He concluded that the most urgent need is for a system that can economically utilize the unused residues with the lowest economic value, i.e. bark and sawdust.

Table 3.3 summarizes the residue utilization for responding sawmills.

Table 3.3.--Residue Utilization for Mills Contacted in a Survey

		Coarse residue[1]	Sawdust	Shavings	Bark
		75 mills reporting	76 mills reporting	70 mills reporting	72 mills reporting
Sold to pulp mills	% of mills	92[2]	39	11	0
	Average % of residue sold	95	72	87	0
Sold to board plants	% of mills	14	28	64	0
	Average % of residue sold	34	69	93	0
Sold as fuel	% of mills	7	20	10	33
	Average % of residue sold	5	77	94	78
Sold for "other" use	% of mills	0	11	9	31
	Average % of residue sold	0	74	76	76
Used for plant fuel	% of mills	10	34	23	49
	Average % of residue sold	15	79	69	73
Unused	% of mills	7	4[3]	0	13[4]
	Average % of residue unused	10	100	0	71

[1]Coarse residue: slabs, edgings, sawmill trim, planer trim.
[2]Read as: "92 percent of the mills contacted reported some sale of coarse residue to pulpmills. On the average, these mills sold 95 percent of their coarse residue to this market."
[3]All redwood mills
[4]Of 13 mills reporting some unused bark, eight were California redwood mills, of which four reported no uses for bark.
Note: percentage figures do not add to 100 percent due to multiple uses reported for most residues.

Source: William E. Moore, Wood Residue Energy Conversion Systems Market, For. Prod. J., Vol. 26, No. 3, March, 1976.

Figure 3.1 reflects the residue production by type of residue.

Coarse Residue: The average production was .405 bone dry units (BDU) per thousand foot board measure (Mfbm) lumber tally. (Unit refers to a volumetric measure of 200 cu. ft.) By weight, this amounts to .486 tons/ Mfbm.

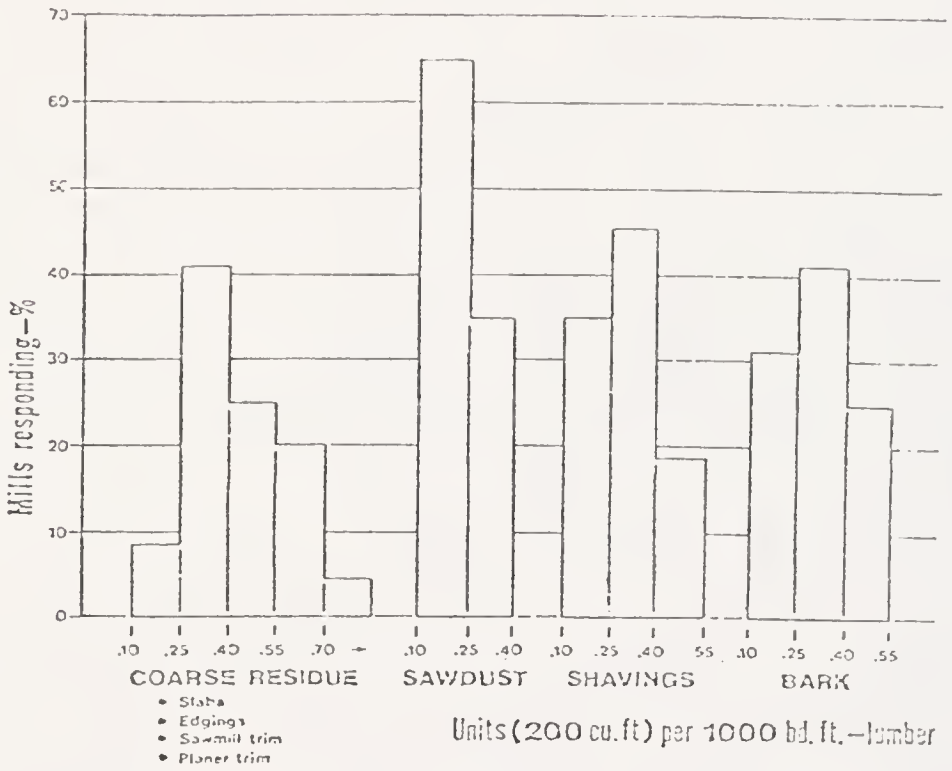
Nearly all the coarse residue was sold as chips to pulpmills. Less than 10 percent of the mills used some of their coarse residue for plant fuel or sold it as fuel to others.

Sawdust: The average amount of sawdust was .224 units/Mfbm. By weight, this is between 1,700 and 1,900 pounds, depending upon moisture content. The largest single use of sawdust was for their own plant fuel.

Shavings: The average production of shavings was .284 units/Mfbm, by weight, 350 to 450 dry pounds. No mills reported any unused shavings.

Bark: Only 13 mills reported data on bark production. The average production was .30 units/Mfbm, approximately 630 to 780 dry pounds. Bark most often was used for fuel.

Figure 3.1.--Residue Production Log Type of Residue



*Read as: 42 percent of the mills responding reported coarse residue production of .25 to .40 units/Mfbm lumber tally.

Source: Moore, 1976

Future production of mill residues will be influenced by several factors. Christenson (1976) and Knap and Bethea (1975) hold that saw mill operators will be seeking ways to increase lumber yield from the same number of logs, thus decreasing mill residues.

Schweitzer reports that under current circumstances increased forest industries production results in an increase in the volume of mill residues. As reported by the USDA-FS (1973), growth of the forest industry production is expected through the year 2,000.

Christensen (1976) reports that there is a strong economic incentive for the mill operator to reduce residue and to upgrade the residue remaining. Table 3.4 illustrates relative product and by-product values.

Table 3.4.--Relative Product and By-Product Values

	Index of Value to Sawmiller
Lumber	100
Chips	25
Sawdust and shavings	5
Hogged fuel	2-1/2

Source: Christenson, Wood Residue Sources, Uses, and Trends, 1976

Christensen concludes that the quantity of sawmill residue for fuel will decline due to competition from product residue users. He holds that relief in wood residue supplies for both product and fuel users lies in the increased use of forest residues.

The author cited a study (Mason, 1973) in which it was found that upgrading sawmills only to present off-the-shelf technology and methods could increase solid wood recovery by 27 percent. Table 3.5 predicts the decrease in residue volumes which would result.

Table 3.5.--Predicted Decreases in U. S. Mill Residue Volumes Resulting from Mill Upgrading

Residue	Millions of Cubic Feet		
	Present	Predicted	Change
Chips	1,598	1,530	-4%
Sawdust	806	517	-36%
Shavings	695	533	-23%

Source: Christenson, 1976

He predicted that sawmill operator will be seeking ways such as mill upgrading to increase sawlog production while decreasing residues and hogged fuel production.

Knox and Bethea (1975) explained a sawmill improvement program launched in mid-1973. The program uses recent research from the U. S. Forest Products Laboratory to improve lumber recovery. During the first full year of the program, 240 sawmills participated. The estimated effect of the program will be an increase of more than 400 million board feet of lumber per year from the same volume of logs from the client mills. The program involves state and private forestry specialists, working with the researchers to evaluate the mill's lumber recovery factors (LRF)--the board feet of lumber yield divided by the cubic footage of logs involved. This and several other factors are investigated and "fed into a computer to provide the mill owner with prescriptions for improving quality control."

Knox and Bethea state, "The sawmill improvement program has been a cooperative state-federal effort in 32 states, with state crews doing the mill study and Forest Service and state specialists providing program leadership.

The authors cite efforts by the State of Florida to increase timber utilization in the state. Since 1970 when Florida received a grant from the Forest Service to study the forest resource and project the economic picture for the next 30 years, the state has added 11 utilization specialists to their staff to work with loggers and sawmills. Florida hopes to add more manpower and to cooperate with industry and with other state and federal agencies, as well as to work with the public to increase the wise use of timber resources.

Schweitzer and others (1975) report that increased production by Montana forest industries has resulted in more mill residues. Table 3.6 compares residues produced in 1966 and 1969.

Table 3.6.--Mill Residues Produced and Percent Used in Montana, 1966 and 1969

Year	Residues	MM Ft^3		Used Percent	
1969	Coarse	61		87	
	Fine	57	118	60	74
	Bark		38		28
1966	Coarse				
	Fine		73		66

Source: Schweitzer and others, 1975

Schweitzer and others (1975) noted planned increases of mill capacities in Montana which may result in increased mill residues. (See Table 3.7.)

Table 3.7.--Announced Plans for Expansion of Production, Montana, 1974

Product	*Additional capacity*
Lumber	100 million board feet annually
Plywood and veneer	300 million square feet annually
Particleboard	100 million square feet annually
Paper and pulp	700-750 tons per day

Source: Schweitzer and others, 1975

SUMMARY

Mill residues consist of coarse, fine and bark residues. The majority of evidence suggests that these materials will be in high demand since they are more accessible than forest residues. There is reported to be a close balance between coarse (chips) and pulpwood demand. Fine residues in the future are predicted to be committed to particleboard manufacture.

The literature reports that the mill residues most economical for fuel use by the forest industries are bark and sawdust.

The present trend in Montana is for mill residues to increase with increased production of wood products. However, the literature suggests that future efforts by the lumber industry to improve lumber recovery will cause the volume of mill residues which will be available for fuel use to decline.

4. POTENTIAL FOR WOOD AS AN ENERGY RESOURCE

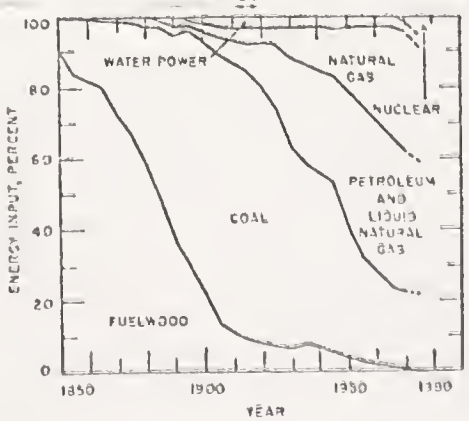
4.1 WOOD FOR DOMESTIC FUEL

It should be noted that most material relating to present trends in domestic use of wood for fuel in Montana (and in the nation) was written before the present increases in fuel prices. Schallau (1975) points out that the oil embargo and its related socio-economic changes may cause considerable moderation in demand for timber products.

Corder (1973) states that the quantity of wood burned for fuel in the United States has been decreasing continually since the late 1800's. "Sixteen percent of the roundwood cut in 1952 was for fuelwood while in 1969, it was only 6 percent." Figure 4.1.1 depicts the use of fuelwood for energy compared to other sources of energy in the United States from 1850-1980.

In the 1850's, approximately 18 cords of wood per year were used to heat an American home (Corder, 1973, quoting Schurr and Netschert, Energy in the American Economy, 1850-1975, Johns Hopkins Press. 1960). One cord of roundwood is equivalent to 85 feet or to one 2,400-pound boen dry chip unit (Host and Lowery, 1970).

Figure 4.1.1.--Sources of Energy in the United States



Source: Corder, 1973, citing Cook, Earl. "The Flow of Energy in an Industrial Society." IN: Energy and Power, A Scientific American Book. W. H. Freeman and Company. Pp. 83-91. 1971.

Domestic use of wood for energy in Montana compared to national consumption was reported by Wheeling (1976a). Tables 4.1.1 and 4.1.2 show that the percent of Montana homes which used wood for cooking, home heating, and water heating in 1970 is slightly higher than the national average. However, Montana does follow the nationwide trend of using wood for energy in only a small percentage of homes.

Table 4.1.1.--Residential Appliance Data for Montana from 1970 U. S. Census of Housing (as reported in AGA Gas Facts, 1971)

Fuel Type	Cooking			Home Heating			Water Heating		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Total Units	121,200 100%	96,100 100%	217,300 100%	121,200 100%	96,100 100%	217,300 100%	121,200 100%	96,100 100%	217,300 100%
Wood	500 0.4%	2,400 2.5%	2,900 1.3%	200 0.2%	3,900 4.1%	4,100 1.9%	100 0.1%	500 0.5%	600 0.3%

Source: Adapted from Wheeling, 1975a

Table 4.1.2.--Residential Appliance Data for the United States from 1970 U. S. Census of Housing as Reported in AGA "Gas Facts," 1971 (Data in 1000's of Housing Units)

uel Type	Cooking			Home Heating			Water Heating		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
otal Units	47,649.8 100%	15,797.3 100%	63,447.1 100%	47,649.8 100%	15,797.3 100%	63,447.1 100%	47,649.8 100%	15,797.3 100%	63,447 100%
Wood	62.5 0.1%	342.6 2.2%	405.1 0.6%	93.7 0.2%	700.6 4.4%	794.3 1.3%	12.8 0.0%	34.4 0.2%	0.

As recently as 1950, wood was used for heating and cooking in a much higher percentage of Montana homes. (See Tables 4.1.3 and 4.1.4.) In rural areas, wood heated 18.1 percent of the homes. Statewide, the percentage was 11.2 percent.

Table 4.1.3.--Residential Appliance Data for Montana from 1950 U. S. Census of Housing (as reported in AGA Gas Facts, 1951)

	Cooking			Home Heating		
Fuel Type	Urban	Rural	Total	Urban	Rural	Total
Total Units	79,700 100%	92,300 100%	172,000 100%	79,700 100%	92,300 100%	172,000 100%
Wood	2,400 3.0%	19,500 21.1%	21,900 12.7%	2,600 3.3%	16,700 18.1%	19,300 11.2%

Table 4.1.4.--Residential Appliance Data for the United States from 1950 U. S. Census of Housing as Reported in AGA "Gas Facts," 1951 (Data in 1000's of Housing Units)

	Cooking			Home Heating		
Fuel Type	Urban	Rural	Total	Urban	Rural	Total
Total Units	28,014.2 100%	14,086.3 100%	42,100.5 100%	27,860.9 100%	13,968.4 100%	41,829.3 100%
Wood	667.1 2.4%	3,483.1 24.7%	4,150.2 9.9%	617.9 2.2%	3,553.3 25.4%	4,171.2 10.0%

Source: Adapted from Wheeling, 1975a.

The Forest Service (USDA Forest Service, 1973) reported that nationwide fuelwood consumption in 1970 was 16 million cords. This included 314 million cubic feet of roundwood from growing stock, 228 million cubic feet of roundwood from other sources such as dead and cull trees and 723 million cubic feet of primary plant residues.

Of this amount, the roundwood was used almost entirely for domestic heating while the plant residues were used both for domestic purposes and for steam power in wood processing plants. The report predicts that fuelwood consumption will continue the overall decline with the exception of the market for fireplace wood.

Green and Setzer (1974) list no separate classification for Montana fuelwood removals; however, removals for posts, fuelwood, and miscellaneous in western and eastern Montana are reported in Tables 4.1.5 and 4.1.6.

Table 4.1.5.--Removals from Growing Stock on Commercial Forest Land in Montana by Total Removals, Post, Fuelwoods, and Miscellaneous Timbering

State	Total Removals	Posts, fuelwood, miscellaneous farm timbers
Western Montana	292,043	1,127
Eastern Montana	32,361	140

Source: Adapted from Green and Setzer, 1974.

Table 4.1.6.--Removals from Sawtimber on Commercial Forest Land in Montana by Total Removals, Post, Fuelwoods, and Miscellaneous Timbering

State	Total Removals	Posts, fuelwood, miscellaneous farm timbers
Western Montana	1,635,237	3,519
Eastern Montana	178,912	438

Source: Adapted from Green and Setzer, 1974.

4.2 WOOD FOR INDUSTRIAL FUEL

Ellis (1976) cautions that, although wood has a role as a national energy source, it cannot "be a panacea for the Nation's fuel problems." Ellis calculated that the total energy available annually from harvesting residues and unused mill residues for 1973 would have been 2.2 quadrillion Btu's--"Equivalent to about three percent of the U. S. energy consumption in 1973." Ellis suggested, however, that much of the forest industries' purchased energy requirements could have been replaced with this resource.

The author concluded, "For the next 10-25 years, the principal users of wood and bark fuels almost certainly will be forest products industries," rather than widespread industrial use of wood for energy.

However, individual states may differ from the national picture in their potential for meeting energy requirements with wood. The Vermont Governor's Task Force on Wood as a Source of Energy (1975) has recommended that possibilities be further explored for the use of wood as a fuel to produce steam for commercial, industrial and municipal heating, and to produce electricity. The Task Force encouraged that the State of Vermont vigorously support a proposed pilot project to test the potential for wood as a fuel for power generation. The report also recommended that a pilot project employing wood to produce steam for heat be undertaken by the State at one of its facilities.

Tables 4.2.1 and 4.2.2 compare two aspects of the wood resources of Vermont and Montana. Vermont's 4,364 thousand acres of commercial timberland produce 10,748 thousand board feet of sawtimber residues, approximately seven percent of the sawtimber residues produced in Montana.

Table 4.2.1.--Area of Commercial Timberland, All Ownerships, 1970

	Thousand acres
Vermont	4,364
Montana	15,983

Source: Adapted from USDA-FS, 1973.

Table 4.2.2.--Logging Residues from Sawtimber, 1970

	Thousand board feet
Vermont	10,748
Montana	135,815

Source: Adapted from USDA-FS, 1973

Mason (1976) reports on the variety of factors which must be considered by the wood products industry in evaluating whether to use wood residues for energy or for raw material in the production of a market product. The author states that wood residues not readily usable in the manufacture of market products and which are at hand are obviously suitable as a source of energy.

Mill residues which have market opportunities, however, must be evaluated so that the greatest value (whether as fuel or raw material) may be obtained.

Mason states, however, that, "it should be recognized that there may be driving forces other than those covered . . . to consider in allocating wood residuals. One certainly is the fact that wood residuals represent an internally generated, secure, relatively pollution-free energy source in a world that does not seem to have too many secure sources left!"

Grantham and Ellis (1974) report that nationwide, 19 percent of all residue produced at primary wood-processing plants was used for industrial

fuel. In the pulp and paper industry, 37 percent of the 1972 energy requirement was met through combustion of bark and spent pulping liquors.

The authors held that growing interruptions in natural gas and increasing difficulty in obtaining adequate standby supplies of fuel oil or propane have resulted in new furnace installations at pulpmills or large wood manufacturing centers generally being designed to burn wood or bark.

In Montana, 20 companies generate steam from wood wastes to power specific portions of their manufacturing processes, such as dry kilns. These companies are listed in Table 4.2.3.

In addition, Hoerner-Waldorf's pulp mill in Missoula and the St. Regis Company in Libby produce electrical energy from steam powered turbines fueled by wood wastes.

Table 4.2.3.--Montana Wood Products Companies Which Use Steam from Wood Wastes for Part of Their Energy Needs, 1977

Company	*Location*	
American Timber Company	Olney	
C & C Plywood	Kalispell	
Del Conner Lumber Co.	Darby	
Diamond International	Superior	
Evans Products	Missoula	
Flodin Lumber Co.	Plains	
Intermountain Co.	Missoula	
Louisiana Pacific Corp.	Deer Lodge	
Louisiana Pacific Corp.	Columbia Falls	
Louisiana Pacific Corp.	Trout Creek	
Missoula White Pine Sash	Missoula	
Plum Creek Lumber Co.	Columbia Falls	
Plum Creek Lumber Co.	Pablo	
F.H. Stoltze Land & Lumber Co.	Columbia Falls	
F.H. Stoltze Land & Lumber Co.	Dillon	
St. Regis Paper Company	Libby	
Thompson Falls Lumber Co.	Thompson Falls	
Diehl Lumber Co.	Plains	
U. S. Plywood	Bonner	
Yellowstone Pine	Belgrade	
Hoerner-Waldorf	Missoula	electric power
The St. Regis Company	Libby	electric power

Source: Communications from Montana Department of Natural Resources and Conservation, August 26, 1976, and January 14, 1977.

Wheeling (1976b) notes that complete data is not available for total use of hog fuel in Montana forest products industries. The author presents examples of wood and process residues used for fuel by several companies. (See Table 4.2.4.)

Table 4.2.4.--Examples of Use of Wood and Process Residues as Energy Sources by Lumber and Paper Industries in Montana in 1974[1].

Company	Fuel	Approximate Use in 1974	Percent of Total Energy Inputs
Hoerner-Waldorf Corporation	Hog Fuel	110,000 tons	9%
	Black Liquor (oven dried)	57,500 tons	57%
Plum Creek Lumber Company	Wood Shavings and Sawdust	54,750 tons 2/ 3/	--
	Bark	16,800-27,600 tons	--
St. Regis	Hog Fuel	370,000 tons	99%

1/ Source: Solid Waste Management Bureau, Department of Health and Environmental Sciences. (4)
2/ Reported in the source document as 150 tons/day average.
3/ Reported in the source document as 1,400-2,300 tons/month average.

Source: Wheeling, 1976b.

The amount and type of mill residues which are used in Montana for wood products industry fuel were investigated by Setzer (1971). A study (Moore, 1976) of Oregon and California mills found similar results.

Setzer (1971) reported on the proportion of used and unused plant residues from lumber and veneer and plywood industries in Montana in 1969.

About 28 percent of the bark was utilized, mainly for fuel. More than 86 percent of coarse residues (material suitable for chipping) was used, largely for pulpwood, and about 60 percent of fine residues (material such as sawdust and shavings) was used, mainly for fuel.

In a study (Moore, 1976) mentioned in Section 3 on the uses, values, and production of sawmill residues by 79 sawmills throughout Oregon and California, the revenue patterns for mill residues were explored. Figures 4.2.1, 4.2.2, 4.2.3, and 4.2.4 indicate the reported net revenues for coarse residues, sawdust, shavings, and bark.

Figure 4.2.1.--Revenue pattern for . . . COARSE RESIDUE to Pulp Mills

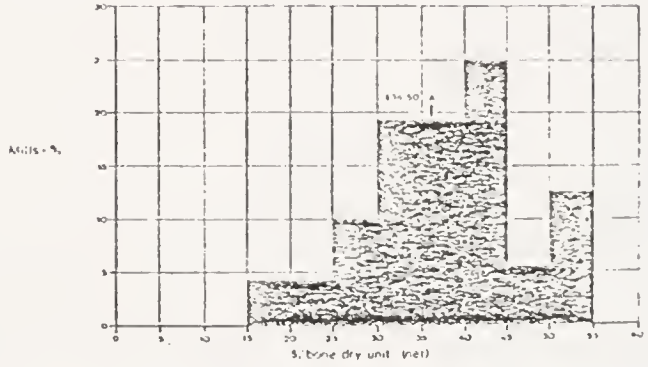


Figure 4.2.2.--Revenue pattern for . . . SAWDUST

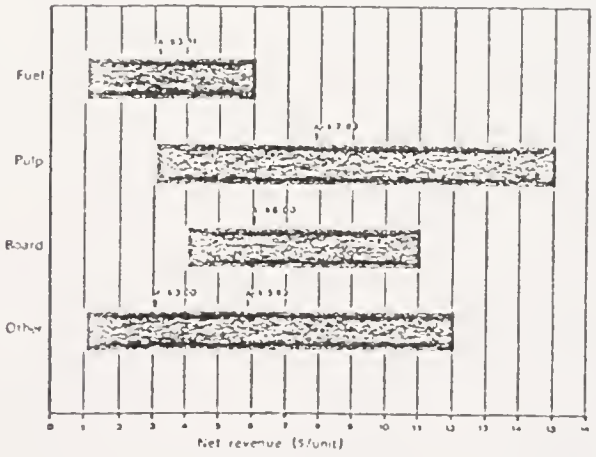


Figure 4.2.3.--Revenue Pattern for . . . SHAVINGS

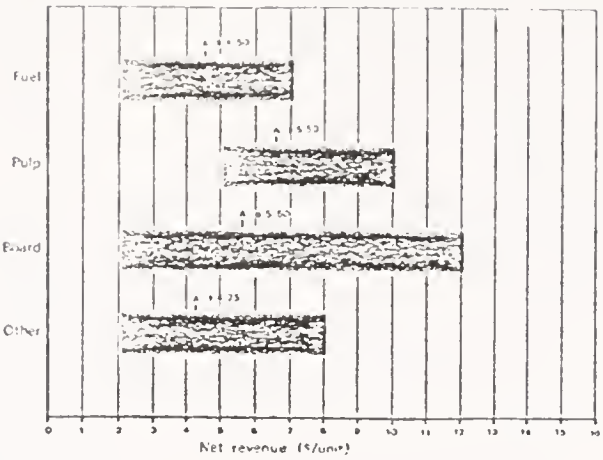
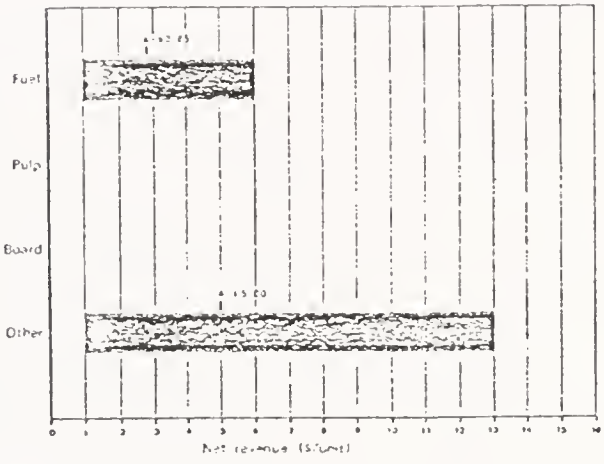


Figure 4.2.4.--Revenue Pattern for . . . BARK



Source: Moore, William E., "Wood Residue Energy Conversion Systems Market," 1976.

Nearly all coarse residues were sold to pulpmills. Sawdust was used as plant fuel, as well as by pulp and board manufacturers. Shavings were mainly sold to board plants which offered a higher price than fuel purchasers. However, the second most popular use reported for shavings was for plant fuel.

Bark was reported to be at the low end of the scale in respect to revenue and variety of markets available. It was found that at $2.85 a unit, bark was the cheapest fuel of all (including coal). It was most often used for plant fuel.

Wheeling (1976b) reports on the estimates of fuels purchased by the lumber and paper industries in Montana. Data for total use of purchased electricity and natural gas are presented in Table 4.2.5 by standard industrial classification (SIC).

Table 4.2.5.--Forestry Sector Consumption of Purchased Electricity and Natural Gas in Montana in 1974

SIC Code	1/ Electricity (1000 KWH)	Natural Gas (1000 MCF)	2/Percent of Mt. Industrial Sales Elec.	Gas	Percent of Mt. Total Sales Elec.	Gas
24 Lumber and Wood Products	235,176	900	4.0%	2.4%	2.5%	1.1%
26 Paper and Allied Products	151,047	4,700	2.5%	12.5%	1.5%	5.8%
Total SIC 24 and 26	386,223	5,600	6.5%	14.9%	4.0%	6.9%

1/ Source: Federal Reserve Bank of Minneapolis. (2)
2/ Source: Gas Requirements Committee of the University of Denver Research Institute. (3)
3/ Forestry manufacturing only.

Source: Wheeling, 1976b.

Junge (1976) explored the use of energy sources by the national forest industry. He cited recent data which holds that fuel oils account for 37 percent of the pulp and paper industry and 58 percent of the wood products industry's purchased energy comes from fuel oils. Natural gas accounts for 35 percent of the pulp and papers and 23.5 percent of the wood products' purchased energy.

Junge compared these energy sources with the net comparable value of hogged fuel (see Table 4.2.4).

Table 4.2.6.--Comparison of Energy Costs for Major Energy Alternatives

ENERGY TYPE	Fuel Oil	Nat'l Gas	Coal	Electricity	Average
Average $/10^6BTU	1.90	0.47	0.69	2.93	1.33
Gross Value of Hogged Fuel ($/unit)*	39.90	9.87	14.49	61.53	27.93
Net Comparable Value of Hogged Fuel ($/unit)**	25.94	6.42	9.42	40.00	18.15

* A "unit" of fuel is equivalent to 200 cubic feet of fuel.
** Net value is assumed to be 65% of the gross value.

Source: Junge, 1976.

Junge concluded that wood and bark residues may be the best bargain economically as an energy resource. However, he cautioned wood product manufacturers to consider present and predicted costs of energy alternatives before deciding on energy uses for individual operations.

Cheremisinoff and others (1976) found that at present oil prices, the larger capital and operating investments of hogged fuel utilization can be justified. They report that the high initial capital investment for hogged fuel steam plants is misleading and that other cost effective parameters should be considered. These include: long term savings from lower hogged fuel costs; less stack emissions; rising conventional fuel prices; shortages of conventional fuels; use of hogged fuel with supplemental fuel; and savings derived from not having to dispose of the wood and bark waste.

4.3 POTENTIAL OF INCREASED UTILIZATION OF FOREST RESIDUES.

An important method of increasing wood fiber yield is close utilization. Barger (1975) summarized the motivation behind efforts toward more complete utilization of forest resources. He stated that more complete utilization of the available wood resource in the northern Rocky Mountains can contribute to meeting the projected substantial increases in the national demand for wood and wood fiber products. Environmental considerations also favor maintaining the use of wood since it is a renewable resource that requires less energy with less attendant pollution than alternative materials.

Barger commented on the large amounts of residue created by present utilization standards and logging practices. In proper amounts these residues can contribute to the forest's nutrient reservoir, reduce erosion, protect seedlings, and provide wildlife cover." However, in the volumes that frequently occur, they create fire hazards, inhibit regrowth, and detract from the forest environment in other ways. The author maintains that harvesting and transportation practices that allow greater use of these materials can solve a major part of the forest residue problem.

Barger (1975) holds that the best approach to residue utilization is through closer timber utilization at the time of harvest. "With few exceptions, relogging to recover material left as residue is not likely to be technically or economically attractive."

The Forest Service (USDA-FS, 1974) Environmental Statement on Slash Disposal in the northern region holds that any increased utilization of residues would materially improve the slash disposal problem. The report cites the potential of presently unused wood for pulp and fiber products, and for power generation.

The report states that timber merchantability standards are currently being increased thoughout the region in order to increase tree utilization. More use of Yarding Utilized Material (YUM) clauses in timber contracts is expected to promote the utilization of wastes. This procedure requires that all larger wood residues be yarded and increases the likelihood that timber purchases will remove borderline logs once the material is concentrated and more is available for removal.

Present contracts also provide for free removal of material that is unmerchantable due to size and/or defect. These and other timber sale practices are hoped to reduce forest residue and increase the available wood fiber resource.

Benson and Johnston (1976) described the condition of logging residues on 34 typical logging units in the Northern Rockies. The authors held that much of the merchantable-size timber in the Northern Rocky Mountain States is in mature and overmature stands. Timber harvesting in these stands over the next several decades will thus involve handling sizable volumes of dead trees, down material, and small understory trees. This residue is of interest as a potential source of wood fiber to help offset increasingly tight saw-log supplies.

The authors found that, under conventional utilization, over 60 percent of the residue had no rotten defect. Nearly half the residue that had rot was sound enough to be potentially usable for pulp, fuel, or fiber products. The authors stated, "a high proportion of residues appear to be sound enough for either fiber or roundwood-product use." Sound pieces under the current minimum for roundwood-product use would be usable for fuel and fiber products "although yarding and handling them may pose some technical and economic problems."

Barger (1976) states that "near-future" uses for significant volumes of forest residues include four areas:

1. Extended utilization for conventional roundwood products can be achieved through revising timber merchantability standards to accept small log diameters, using older dead timber, relaxing cull material standards, and other measures. Utilization of these measures depends on market conditions, and the author states that with the trend toward increased demand of wood products, these materials will become marketable.

2. Use for pulpwood is expected to increase due to the close balance between chippable mill wastes and pulpwood demand which presently exists. Barger states that, with greater efficiencies in plywood and lumber manufacture, mill waste chip supply may decrease. As the cost of mill-waste chips increases, the author expects that forest residues will become economically viable for pulpwood.

3. The author expects the particleboard and fiberboard industries to continue to use fine mill wastes at low cost for their raw material. He maintains that expansion of this industry during the next few years will probably be based on mill residues rather than more costly forest residues.

4. Use of forest residues as an industrial fuel by wood products industries is expected to expand. The author notes, "Recent developments in wood combustion technology have dramatically improved the efficiency of wood-fire furnaces and have succeeded in meeting rigorous air quality standards." Mill residues which are unsuitable for pulp or particle board use will continue to

meet part of the industry's fuel need. The author expects, however, that as the industry expands its capacity to use wood fuel, mill residues will be insufficient, and forest residues will become the next alternative. Forces affecting this trend include increasing alternative energy costs, physical unavailability of other fuels, and the need to develop self-sufficiency.

The cost of utilizing forest residues was investigated by Withycombe (1975a). The collection of residues and chipping at a central facility involved costs of logging and hauling. These are listed in Table 4.3.1.

Table 4.3.1.--Average Costs of Logging and Hauling in Region One (1972 dollars)

	Dollars per Thousand Board Feet	Dollars per Ton
Logging cost	$27.80	$13.90
Hauling cost	13.87	6.94
	$41.67	$20.84

Source: John Host, "Lumber Production-Analyzing Costs, Sales, and Supply Relationships," Forest Products Journal, Vol. 24, No. 11, p. 52.

Allowing for inflation from 1972 to 1976, the approximate cost was $26 per ton.

Debarking and chipping at a central chipping facility would be $5 per ton, for a total cost of $31 per ton.

Erickson (1975) (AIChE) has estimated the possible recoverable volume of forest residues produced annually in the United States. (See Table 4.3.2.) He states that almost two-thirds of the annual production of residues is recoverable. Erickson reports that the quantities of logging residues left in

many stands in western forests are "staggering when compared to eastern harvesting operations." He cites residues from logging operations in the Pacific Northwest varying from 4-170 dry tons/acre in comparison with 50-20 wet tons per acre in the East. Erickson holds that economic barriers to the use of forest residues in the west include the high yarding costs (he reports $12 per dry ton, and the fairly large quantities of chips still available to pulp mills from primary processing plants at a reasonable cost.

Erickson holds that a major breakthrough in improving harvesting efficiency and utilization has been the development of systems for harvesting whole trees. These systems operate most favorably on fairly gentle terrain and in clearcut situations. He reports, "The utility of these systems shows promise for many sections of the Rocky Mountain Area . . . and is under study." One advantage of whole tree chipping is that there is no slash residue. In order to increase the desirability of the chippings for pulpwood, research is under way to remove the bark from wood chips.

Table 4.3.2.--Estimate of Forest Residues Produced in the United States Annually (Billion Cubic Feet)

Source of Residue	Volume Available*	Volume Possibly Recoverable
Residue from logging operations	3.5	3.0
Fire, disease and insect damaged timber	4.5	2.0
Unused, precommercial thinning	1.5	1.0
Totals	9.5	6.0

*Forest Residues--A Resource. U. S. Department of Agriculture, Forest Service, Forest Products Lab. brochure.

Withycombe (1975a) does not foresee any substantial reduction in the volume of forest residues in the present decade. "The only significant use of forest residues which appears economically justified is the production

of pulp and paper." The author estimates that logging residues and 5-D wood would provide about 6 million tons annually in the Northern Rocky Mountains. This would allow an increase in pulp manufacture to about four times its current level.

Given an expected 30-40 percent increase in the next five years in pulp production, the demand on forest residues from this industry will not have an impact on total supply.

SUMMARY

The statistics available on demand for wood as a domestic fuel predict a decline in use. However, this data pre-dates the oil embargo which may have caused a moderation in trends.

The majority of evidence suggests that, nationwide, wood could meet only a small percentage of the total U. S. energy requirement. Individuals states, however, may differ from the national situation and may warrant further study, as exampled by the efforts to the State of Vermont.

Forest residue utilization is expected to increase due to the increased demand for wood fiber products and fuel. Timber merchantibility standards and close utilization logging are examples of practices aimed at increasing wood fiber yields. The literature reports that particleboard and fiberboard manufacture is not expected to turn to forest residues in the near future. The use of 5-D wood for pulpwood will not have an impact on the volume of forest residues in the present decade.

The research reports that the potential of wood for energy is expected to expand in the wood products industry, because of several factors including the desire for energy self-sufficiency.

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